Technological & Engineering Education and Industrial Development in Brazil

Prof. Antônio Henriques de Araújo Junior, PhD

State University of Rio de Janeiro

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Brazil in Figures

Population (2016): 211 Million inhabitantes, 5th largest population

84.3 % of the population is **urban** (178,168,858 people in 2017)

The **median age** in Brazil is **31.7 years**.

Extension: 8,51 million km2 (3,523,689 sq. Miles), 5th largest country

GNP (2016): 2,7 Trillion US$; Exports: 242,178 billion (2016) 8th largest economy

Education:

Amid Brazilian universities, **18** are recognized as being **among the top 1000** in the world. The University of São Paulo (USP) is considered the best higher education institution in Latin America, and the 143th best in the world.

More than 8 Million studentes enrolled in universities:

2,368 Higher Education Institutions; **33,000** undergraduate courses

3,741 post-graduate program; Brazilian graduate programs deliver **13,000** PhD degrees per year.

More than **100,000 researchers and scholars are engaged in research** at private and governmental institutions.

Education as a tool for social transformation

- Social transformation is the process by which an individual alters the social status of their parents into a socially achieved status for themselves.
- **Pati (2012)** by discussing social change needs in India points out that (...) the role of education as an agent or instrument of social change and social development is widely recognized today. (…) It is in the **ideological and moral spheres, however, that education is most clearly expected to play a leading role**.
- Education can be used as **a tool to empower the individual**. Societal change comes from the collective transformation of the individuals within that society.
- Education has been chiefly **instrumental in preparing the way for the development of science and technology.**
- Francis J. Brown remarks that **Education is a process which brings changes in the behavior of society**.

Technological & Engineering Education in Brazil

- Engineering is an important activity in Brazil, and important examples of good Engineering are connected to the **establishment and improvement of the Brazilian infra-structure**.
- Good examples of important Brazilian engineering projects can be related to **the civil engineering area: large hydroelectric power plants** (Itaipu, world's largest plant) and the **largest european Vasco da Gama bridge** (Lisbon) was projected and built in partnership with Portuguese engineers.
- The presence of petroleum in the sea floor (depth as high as 2 miles) generated new and very modern technologies. Innovations in processes were abundant in this field. Petrobras has one of the most modern research labs in this area, in partnership with the Federal University of Rio de Janeiro. Brazilian engineers in the oil and gas exploration, are proud of their deep waters records.
- Brazilian engineers from INPE (National Institute of Space Research) collaborate with the Chinese Academy of Space Technology to develop **a construction program of two advanced remote sensing satellites, called the CBERS** Program (China-Brazil Earth Resources Satellite, Satellite Sino-Brazilian Land Resources). The Brazilian investment in this project exceeds 300 million dollars
- And last but not least, Brazilian automotive engineers **developed multi-fuel engines** (alcohol produced from sugar cane, gasoline and natural gas). **The whole Brazilian car fleet (approx. 40 million automobilies) runs on such multi-fuel engines.** This is the world's largest program for replacing fossil fuels for automotive purposes.

Technological & Engineering Education in Brazil

- The general interest for Engineering Education in Brazil, exists since the beginning of the 20th century. **This interest**, **became explicit only in 1973** when the Brazilian Society for Engineering Education (ABENGE) was founded.
- The correlation of Engineering, and particularly Engineering Education, with National economic and social development, became an important subject of the yearly congresses of ABENGE.
- **In 2004, the CNI**, Brazilian National Confederation of Industry **launched the INOVA Program aiming to involve the productive sector in the discussion on Engineering Education** and its relevance to the development process.
- **The industry, the government and the University** complemented each other to **form the necessary "triple helix",** which is able to contribute to an effective development mechanism.
- About **300 incubators** of new enterprises exist, in Brazil, in Engineering Faculties which **are responsible for more than 30.000 new jobs and technological products** and services **worth about U$1,3 billion.**

Technological & Engineering Education in Brazil

- According to Lall (1992), (…) *of the larger countries,* ***Brazil has the biggest industrial sector, with an advanced technology*** *in many areas of heavy industry"*;
- Still according to this same author, in case of Brazil and Mexico concerning the the industrial efforts, these countries (…) *are more inward-oriented, with large areas of high effective protection, but with export incentives to partially offset this bias.*



The evolution of PhD Programs in Brazil

- The first movement for the creation of postgraduate courses in Brazil only occurred in the 1960s and in a modest and timid manner.
- The first post-graduation courses to be implemented, in Brazil, in the beginning of the 60s was the Mathematics Master´s course at the Brasilia University and the Pure and Applied Mathematics doctorate program at the Institute of Pure and Applied Mathematics, in Rio de Janeiro, was the first doctorate program to be implemented.
- In terms of higher education, Brazil punches well above its weight. Brazilian universities dominate rankings in Latin America, with 17 Brazilian institutions in the top 50 Latin America QS rankings. Only three South American universities are in the Times Higher Education (THE) world ranking and two of them are from Brazil!
- There are no tuition fees for Brazilian students in public universities (a right established in the Brazilian Federal Constitution) in both under and post-graduation programs. Many public universities also do not charge fees to international students either.
- In a short period of time, in just 50 years, Brazil reached impressive achievement: to form over 13,000 doctors per year, about the same output of France or Germany.
- Brazil currently has more than 100,000 researchers and scholars engaged in research at private and governmental institutions. To assure the good quality of the post-graduation programs they are continuously evaluated using an internationally recognized methodology, conducted by the Brazilian Federal Agency for Support and Evaluation of Graduate Education (CAPES).



The Creation of a Technology Center in Brazil

- A commission was created, in Brazil, in 1946 in order to organize an Aerospace Technology Center;
- In 1950, the Brazilian General Command for Aerospace Technology was created aiming to contributing for the research and development of the aerospace and defense sectors in Brazil;
- Air Brigadier Montenegro, the visionary who proposed an Aeronautics Technology Institute (ITA) in the fifties sought technological cooperation with the MIT;
- Montenegro hired renowned foreign professors and experts from various parts of the world to teach at the Institute, the majority of them from MIT. In the beginning, professors and researchers of 20 countries started teaching in the Brazilian Aerospace Institute;
- The initial salaries had to be considerably high, a requirement to convince them to move to an unknown and poor country, as was Brazil in the '50s;
- The "Smith Plan", had foreseen that ITA should form civilian engineers, to aid in the development of the Brazilian industry, specially in the the aeronautical area.

Beginning of the Aeronautical Industry in Brazil

- The Brazilian government, seeking to develop a domestic aircraft industry, made investments during the 1940s and '50s. However, it was not until 1969 that the Empresa Brasileira de Aeronáutica (EMBRAER) was created as a government-owned corporation. The company, initially, produced a small turboprop passenger aircraft;
- The Brazilian Government contributed to EMBRAERS's early growth by providing production contracts. The company sold solely to the domestic market until 1975;
- Born as a public company since the beginning, Embraer began a privatization process during the nineties, which ended in 1994 with the sale of Embraer by the Brazilian government to private Brazilian investors;
- Goldstein (2002) writing about Embraer stated that (…) *this company transformed itself after privatization to become a world market leader in a high-tech industry traditionally dominated by companies based in member countries of the Organization for Economic Cooperation and Development (OECD)".*
- After privatization, EMBRAER improved its production and business processes and became more efficient.

From a state-owned industry to private management

- EMBRAER was founded in 1969, as a public company in the Aerospace Technology Center (CTA, in the Portuguese acronym) which belonged to the Aeronautics Ministry, with State-driven investments. The company remained in that status until 1994:
- According to to Goldstein (2002) *"the production (at EMBRAER) started in the 1970s in co-operation with foreign partners, under co-production and licensing arrangements designed to achieve rapid market penetration without excessive technological dependence"*.
- Dahlman and Frischtak (1993) reported that (…) *The CTA, an umbrella organization for aeronautical research modeled on the Massachusetts Institute of Technology, grew to become ´probably the most advanced research [institution] among industrializing countries´and led to the establishment of sister institutions devoted to technical training (Instituto Tecnológico da Aeronautica (Institute of Aeronautical Technology) (ITA) and aerospace research (Instituto de Pesquisas Espaciais, INPE)"*.
- The foundation of EMBRAER as a state-owned company, if on the one hand got important technical and technological support from the Brazilian State, with the creation of a high-quality Technological Institute, which supplied the company with highly qualified technicians, engineers and researchers, on the other hand constituted a strong factor restricting the growth of the company and the development of more sophisticated products that required high amounts of investment, which the Brazilian State at that time could not afford;

From a state-owned industry to private management

- in 1992, the Brazilian government decided to include Embraer in the list of State-owned enterprises to be sold.
- The privatization process was completed in 1994; four large Brazilian groups took control over the company´s capital. The new owners hired outside executives and injected US$ 413.6 million.
- Production methods and processes were improved, including substantial investment in IT systems;
- Services such as site maintenance, transportation, catering, security and machinery upkeep were outsourced and the payroll fell to 3,849 workers at the end of 1996. Nowadays, EMBRAER has moren than 20,000 employees in five continents.
- With new investments, in the 1990s the company started developing more sophisticated products, such as the regional jet family ERJ 135 and 145, with 45 seats that became a sales success, dominating this segment in the main international aviation market in the United States United.
- The next step was new investments for the creation of the EMB 170/190 aircraft line, a bet in the segment of 70 to 120 seats classified as E-Jets. They were a success with 878 firm orders and 915 purchase intentions, which were soon associated with a new niche market, occupied by both major and low-cost companies.

From a state-owned industry to private management

- In 2009, the launch of the KC 390 program, a tactical / logistical transport and in-flight refueling aircraft developed and manufactured by Embraer Defense and Security, a subsidiary of the Embraer group, was formally announced.
- This aircraft establishes a new standard for medium military transportation, aiming to meet the operational requirements of the Brazilian Air Force, replacing the C-130 Hercules.
- To date, EMBRAER has already announced KC 390 sales to Air Forces of Argentina, Chile, Czech Republic, Portugal and Sweden (In negociation).
- In November 2011, Embraer announced the development of revamped versions of the second-generation E-Jets family with a 144-seat version and a maximum take-off weight of 59,400 kg.

KC 390

New E2 Generation and Phenom 100

EMBRAER in Figures

US$ 21.9

Backlog (Firm orders) of aircrafts as of 2015

US$ 8.62

Billion is the Company Market Value

Us$ 0.90

Billion was theCcompany EBITDA as of 2014

Us$ 6.78

Billion was the cCmpany sales as of 2014

World's largest manufacturer

of commercial aircraft with up to 130 seats. Embraer is one of the leading companies in the global aerospace sector

82 light and 38 large jets delivered in 2015 by the Company in the Executive Aviation sector

267

firm orders in 2015 for the E-Jets-E2 program

With 101 aircraft delivered in the year, the Company maintained its

leadership

In the 70-130 seat commercial aircraft category, with more than 50% of sales and 60% of deliveries worldwide

EMBRAER´s Sites outside Brazil

Conclusions

- To transform society, improving social conditions of a country it´s necessary to invest in education. Finland and Korea are good exemples of social development through education.
- The need for specific *technological effort* to acquire technological capabilities also rises with industrial development. Easy capabilities may be acquired by brief training combined with learning-by-doing (i.e., repetition without technical search, investment or experimentation). However, More difficult capabilities necessarily require more training and effort to master technological knowledge, with concomitant risk and uncertainty.
- As technologies become more complex, the development of capabilities runs into problems of appropriability, externalities, lumpiness and requirements of very specialized skills (Teece, 1989), policies may be needed to overcome these problems in firmlevel efforts. The policies must also cover the development of *institutions* external to firms, to provide information, standards, basic research and other similar “public goods” relevant to capability development.
- The creation of graduate, master's degrees and doctorates programs is part of the process of technological qualification of a country. The training of highly qualified specialists, however is necessary, but not sufficient. The process of creating technology must involve cooperation and technological development together with national and supranational industries.
- In the Brazilian case, it was necessary to increase collaboration in research-based technology between universities, research institutes and industrial companies.
- And, finally, the articulation of well designed public policies and an integrated strategic planning are part of this industrial development process.

Thank You Very Much!

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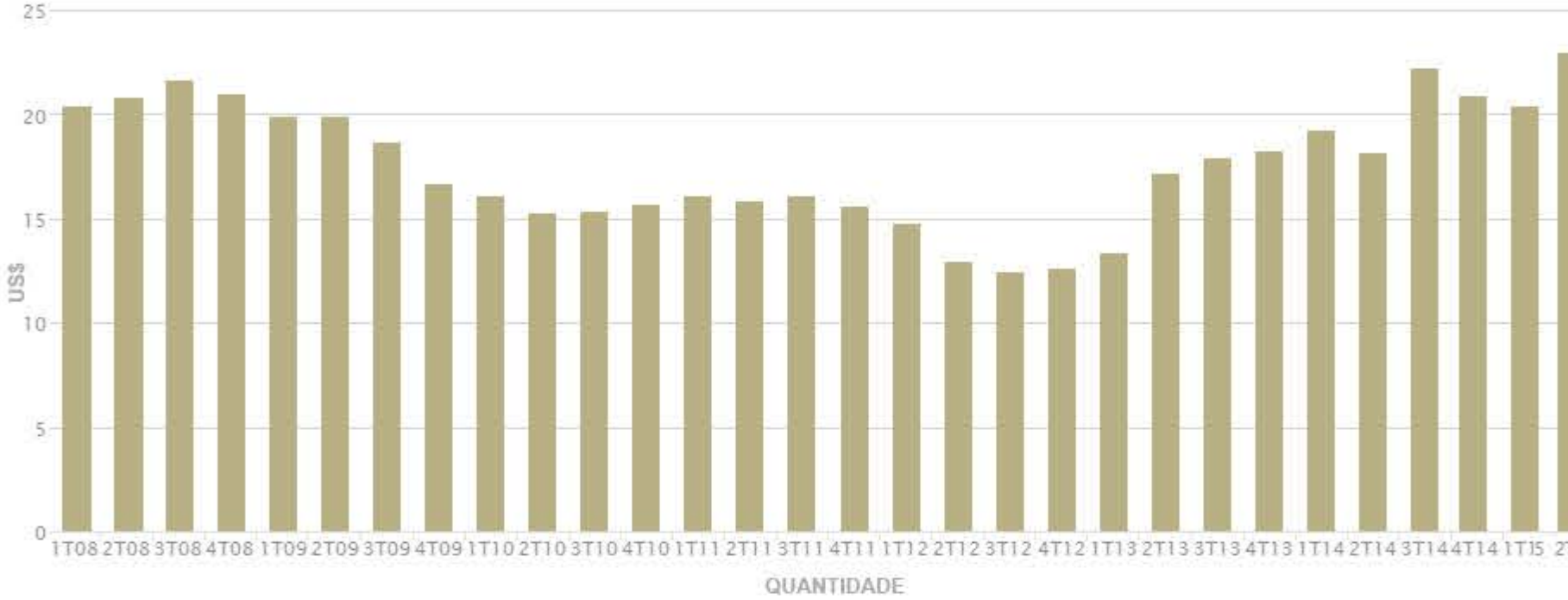
RECEITA, LUCRO, PEDIDOS E ENTREGAS

EVOLUÇÃO DA CARTEIRA DE PEDIDOS* - US$ BILHÕES



EVOLUÇÃO ANUAL DA RECEITA LÍQUIDA
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EVOLUÇÃO ANUAL DO LUCRO LÍQUIDO
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